Surface Water Indicator Development

EMAP

EPA

The Quest for Indicators

- It all starts with an expression of the assessment question – this provides:
  - some sense of the environmental measures that will be needed,
  - the form in which the summary is desired, and
  - target population of interest (design related)

- Illustrate with Examples from EMAP

EPA's Mission

Impetus for EMAP

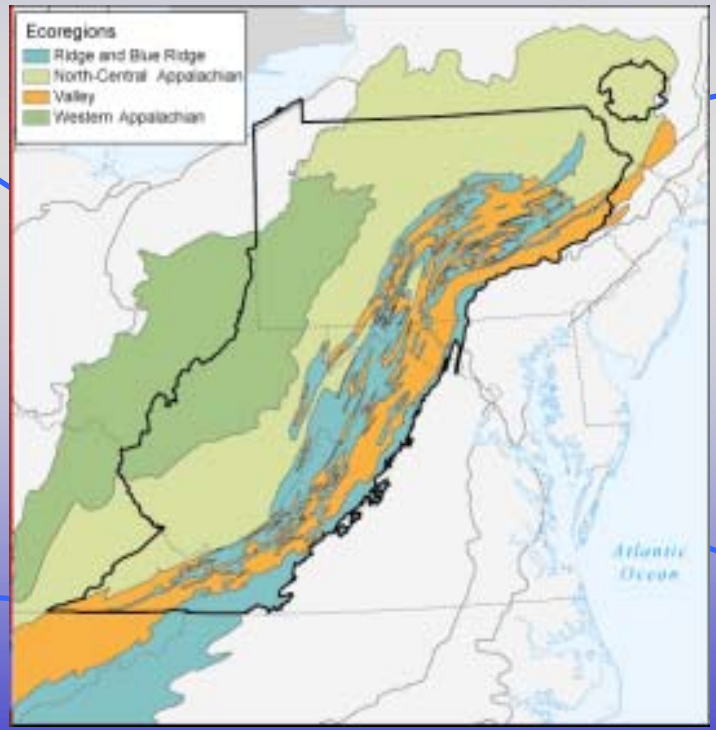
- ***"What do you mean you don't know how many acid lakes there are?"***
  - William Ruckelshaus - EPA Administrator - early 1980s

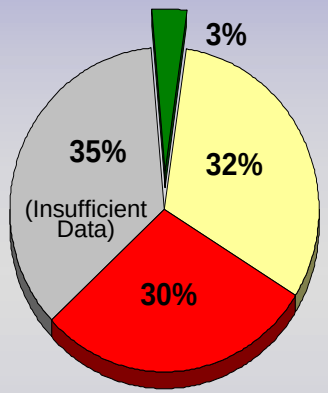
- ***"Good News - Based on my years in the environmental movement, I think the Agency does an exemplary job of protecting the nation's public health and quality of the environment."***

- ***"Bad News - I can't prove it."***
  - William Reilly - EPA Administrator - 1989

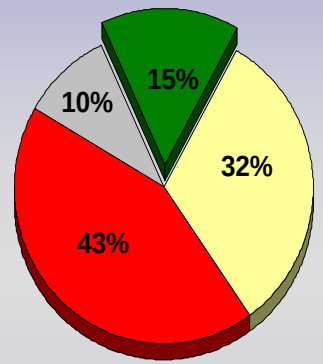
Example EMAP Assessment of Ecological Condition

Fish Index of Biotic Integrity
example from Mid-Atlantic
(90% CI = ± 10%)

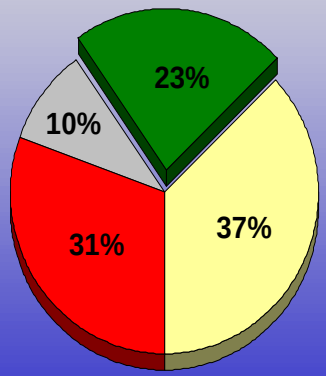




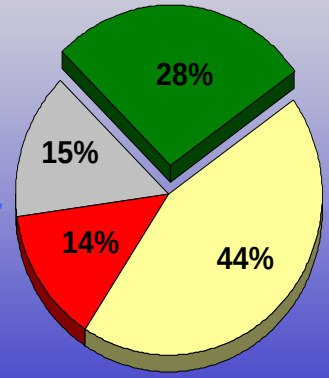
Western Appalachians



No.-Central Appalachians



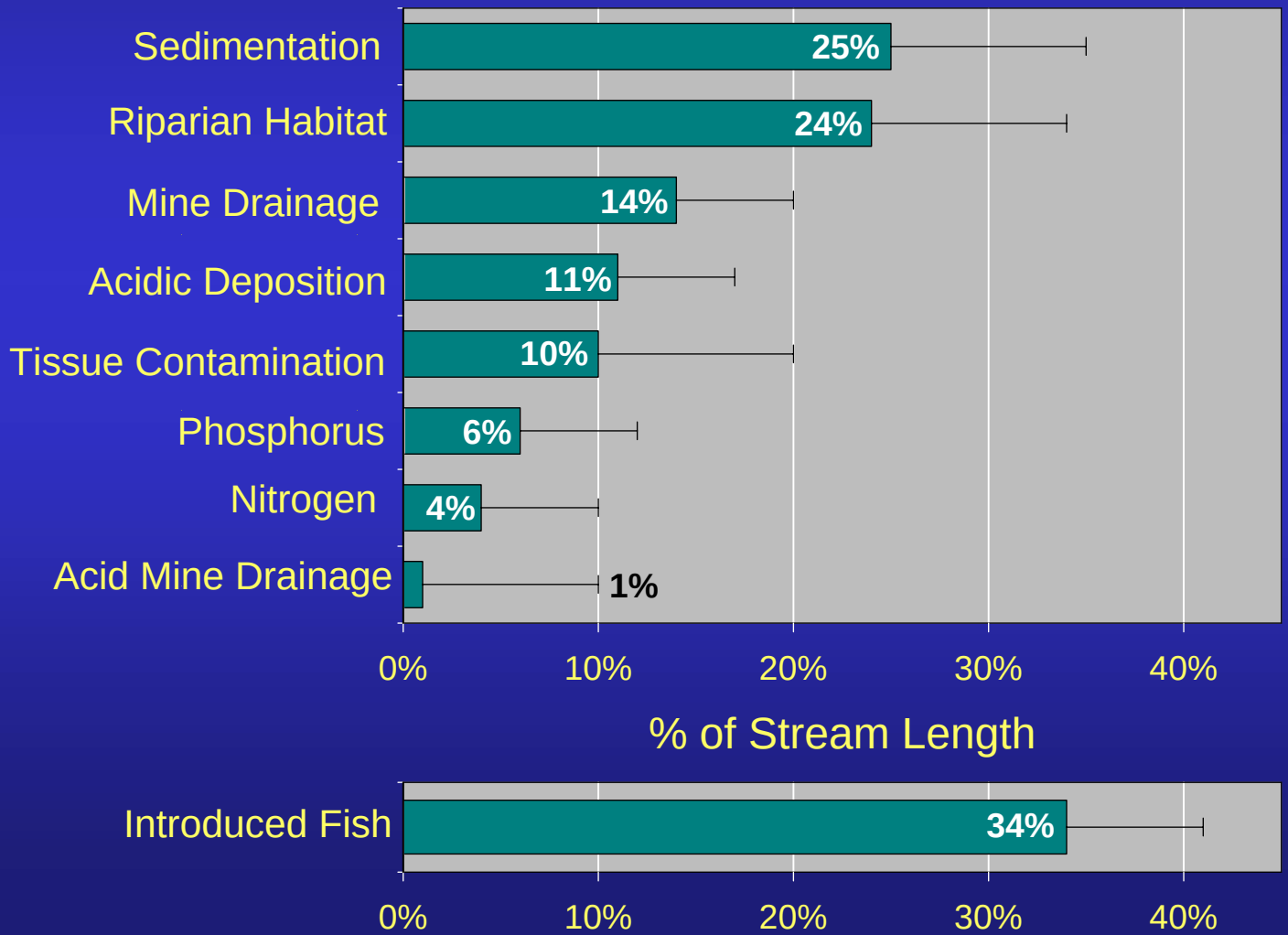
Valleys



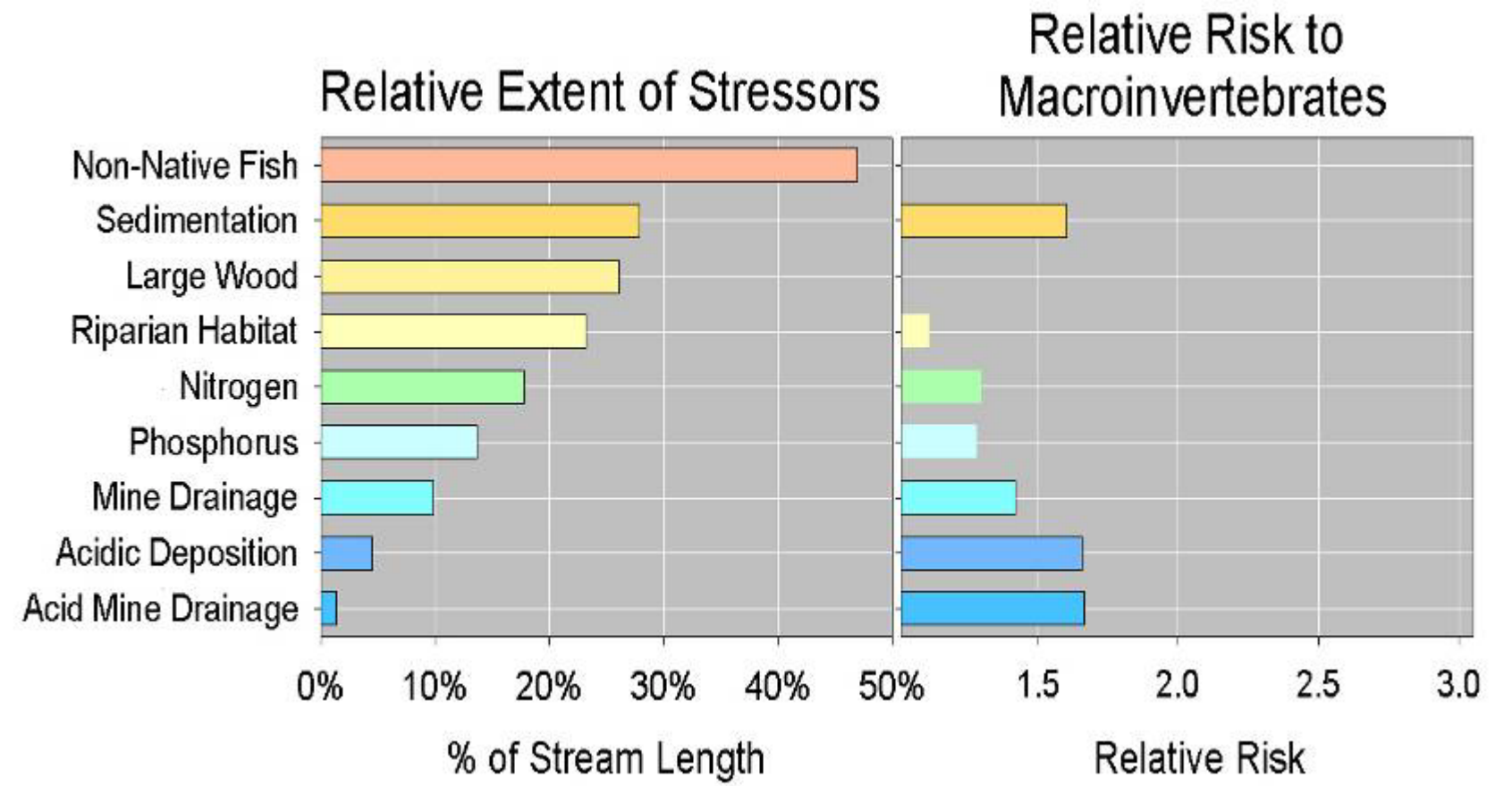
Ridge and Blue Ridge

Example EMAP Assessment - Ranking of Stressors

Stressor ranking example from Mid-Atlantic

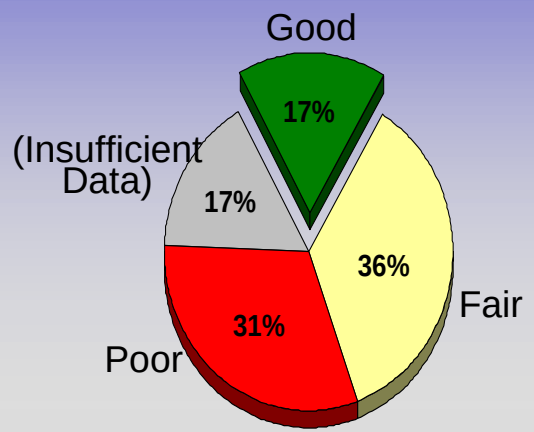


Relative Risk

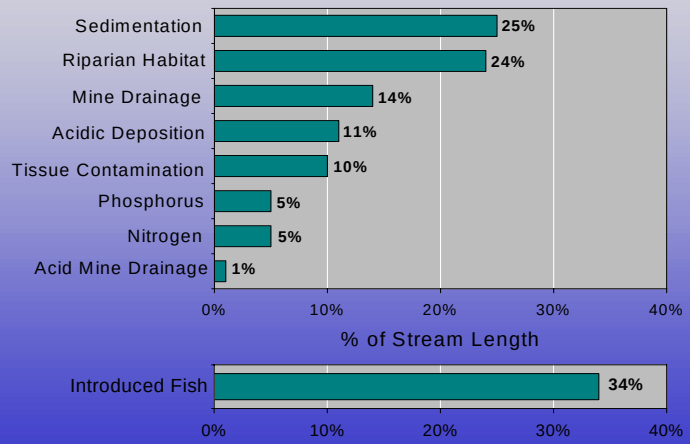


Surface Water Indicator Development

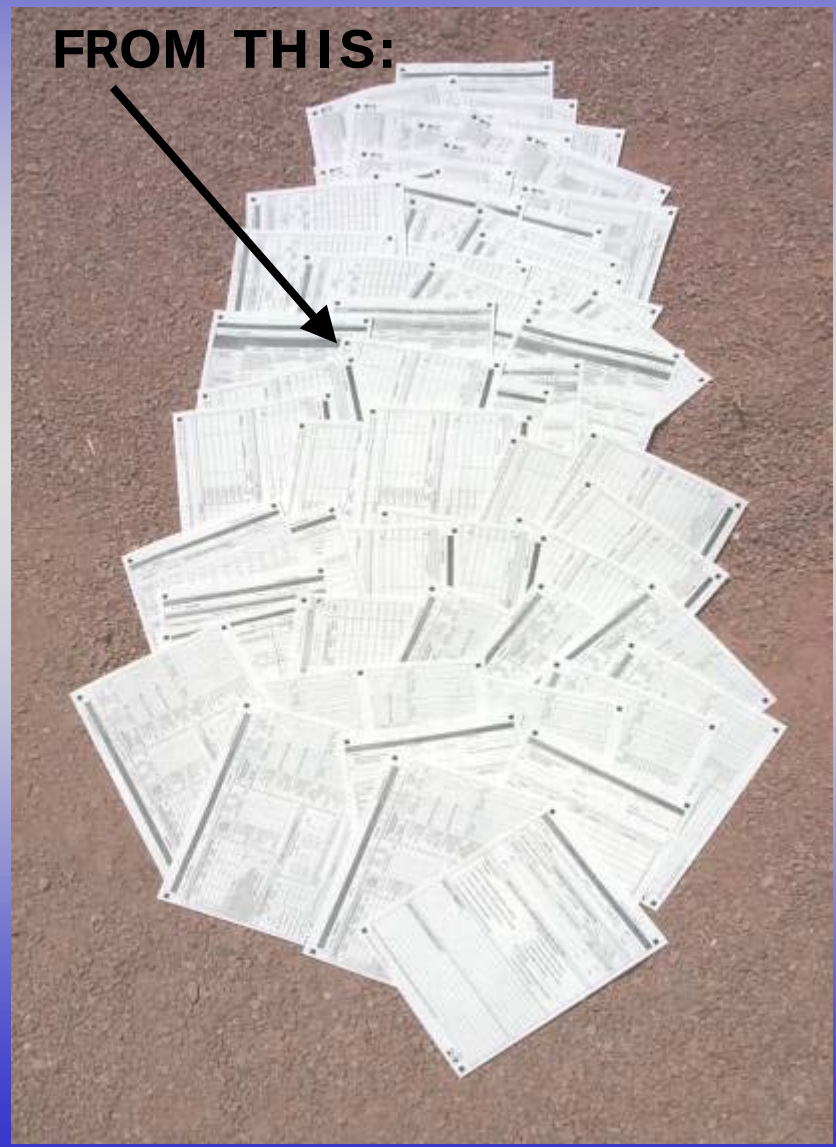
HOW TO GET TO THIS



Proportion of Stream Length

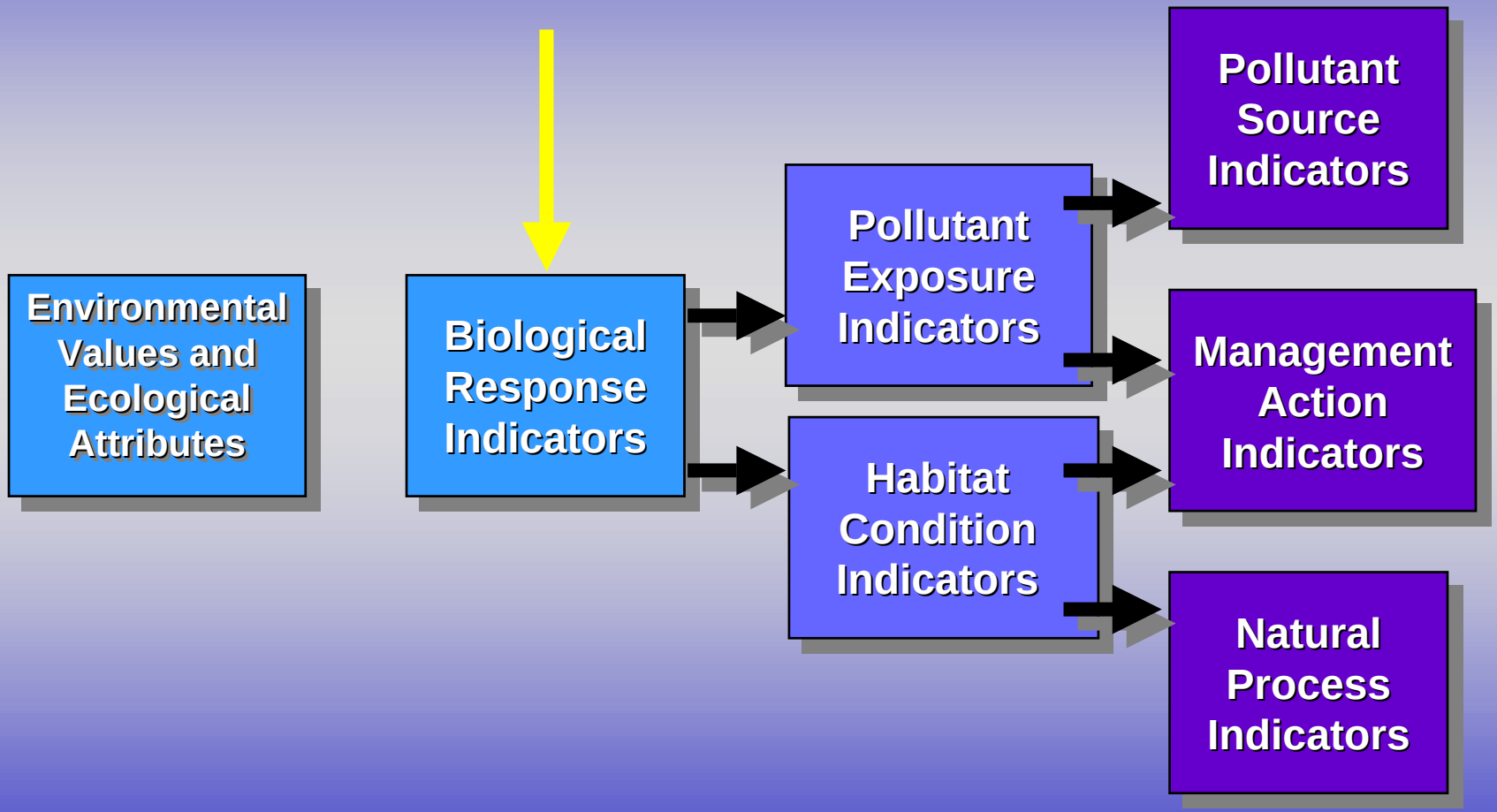


FROM THIS:



Increase Use of Direct Measures

Indicator Strategy



Indicator Philosophy

- Ecological condition based on biological indicators
  - Use whatever works best:
    - multimetric approaches (e.g., Indices of Biotic Integrity)
    - multivariate approaches (e.g., predictive modeling/ RIVPACs)
    - single metrics (e.g., EPT Taxa Richness)
  - All aimed at assessing biotic integrity:

  "a community of organisms having a species composition, diversity and functional organization comparable to those of natural habitats within a region"

- Use complete suite of indicators of physical, chemical and physical habitat to rank stressors and diagnose impairment
- Set expectations based on reference conditions

Indicator Approach

Indicator Criteria

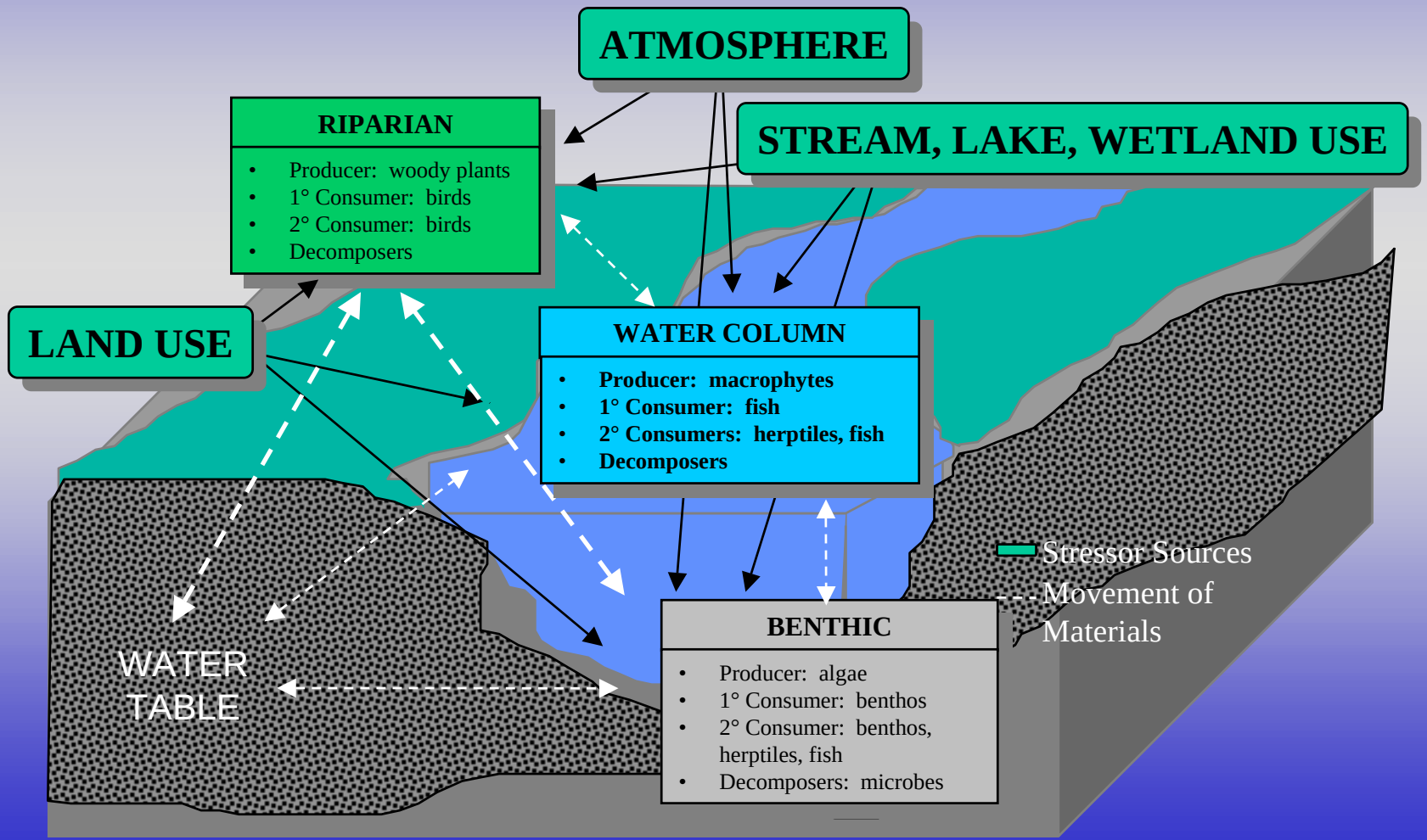
- What can we (realistically) measure in a sample survey?
- How can we best measure it?
- How variable is it?
- How responsive is it?
- Can we score it?

Indicator Approach

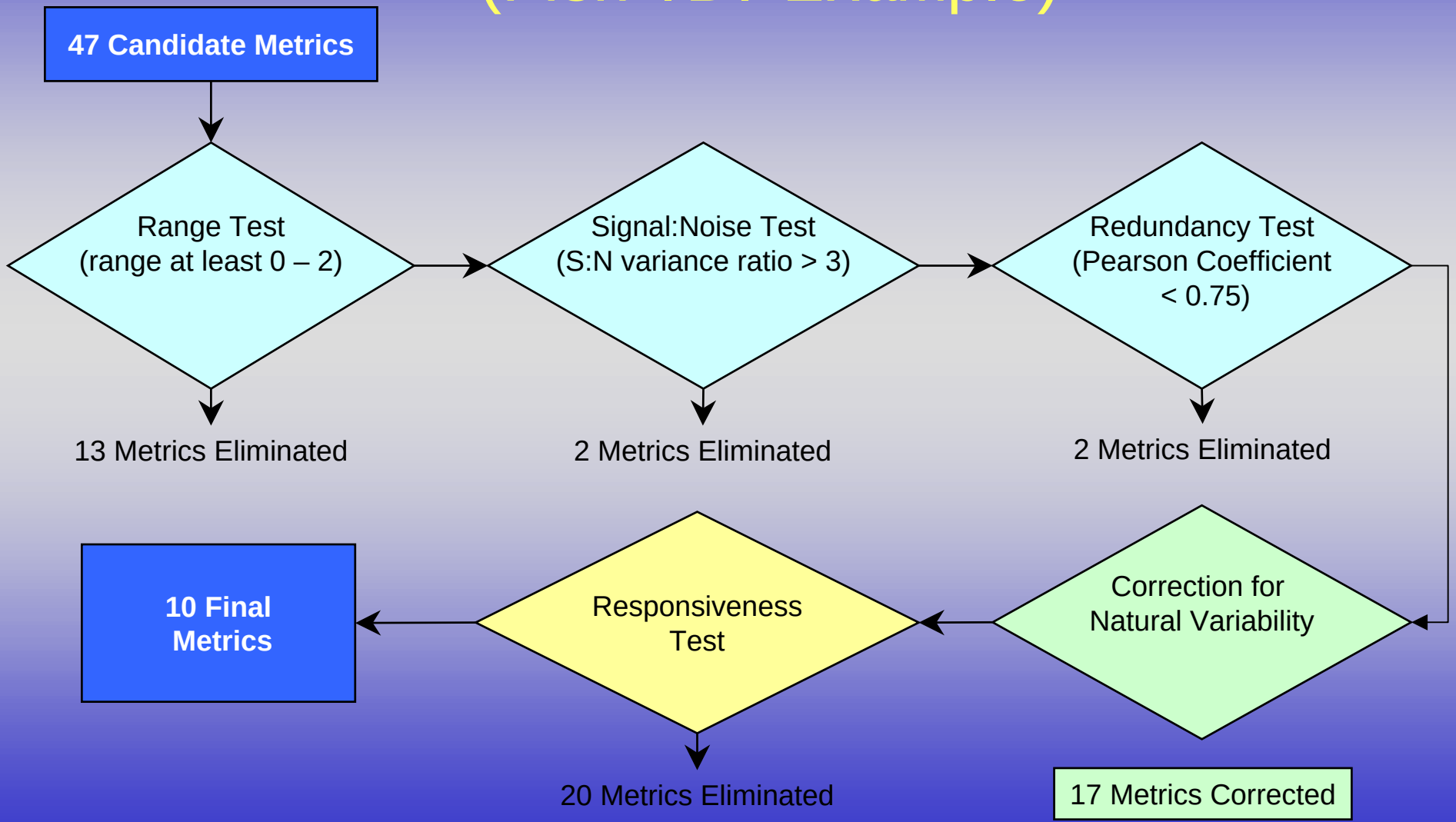
Indicator Criteria

- *What can we (realistically) measure in a sample survey?*
- How can we best measure it?
- How variable is it?
- How responsive is it?
- Can we score it?

Indicator Approach
What we can measure?



Index Development Approach
(Fish IBI Example)

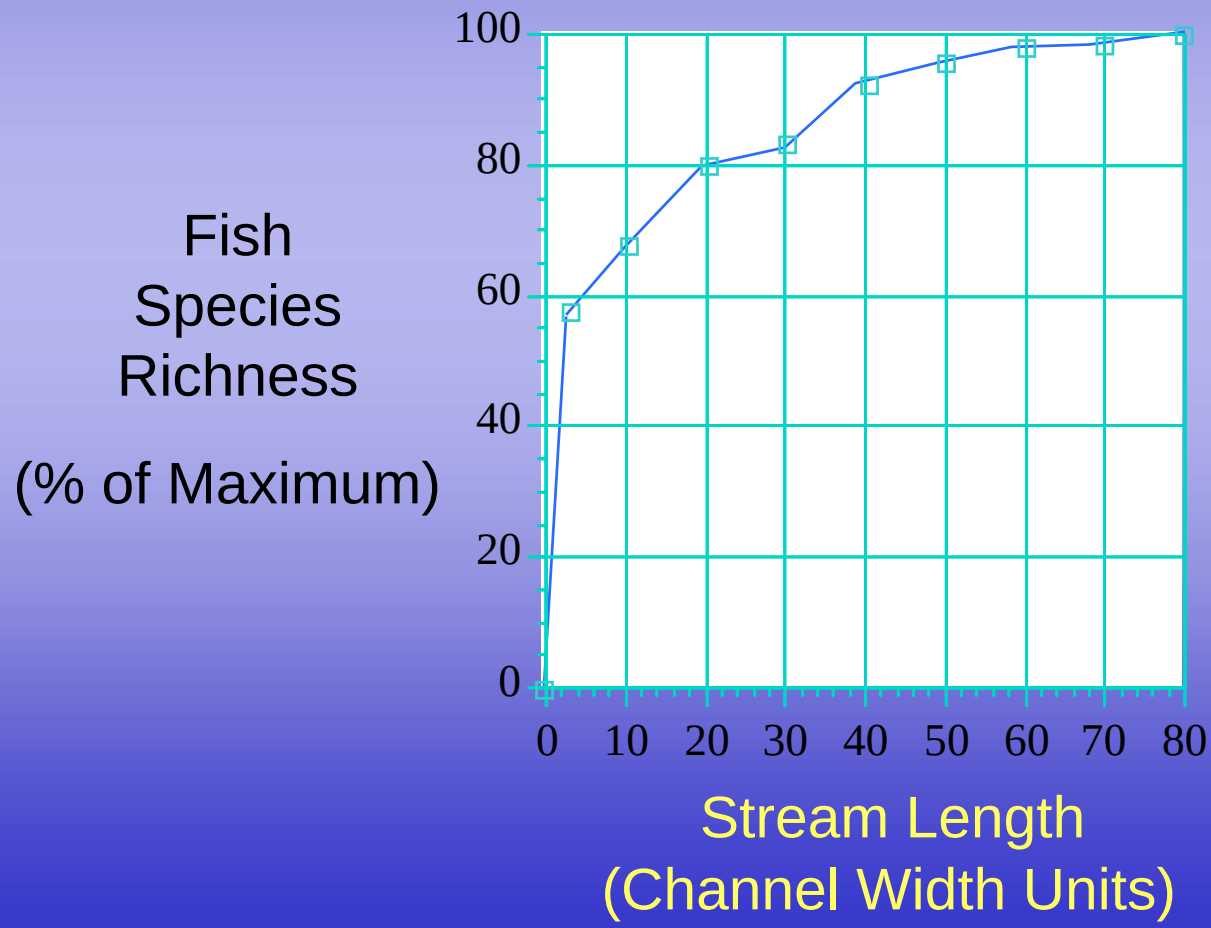


Indicator Approach

Indicator Criteria

- What can we (realistically) measure in a sample survey?
- *How can we best measure it?*
- How variable is it?
- How responsive is it?
- Can we score it?

Indicator Approach
How do we measure?

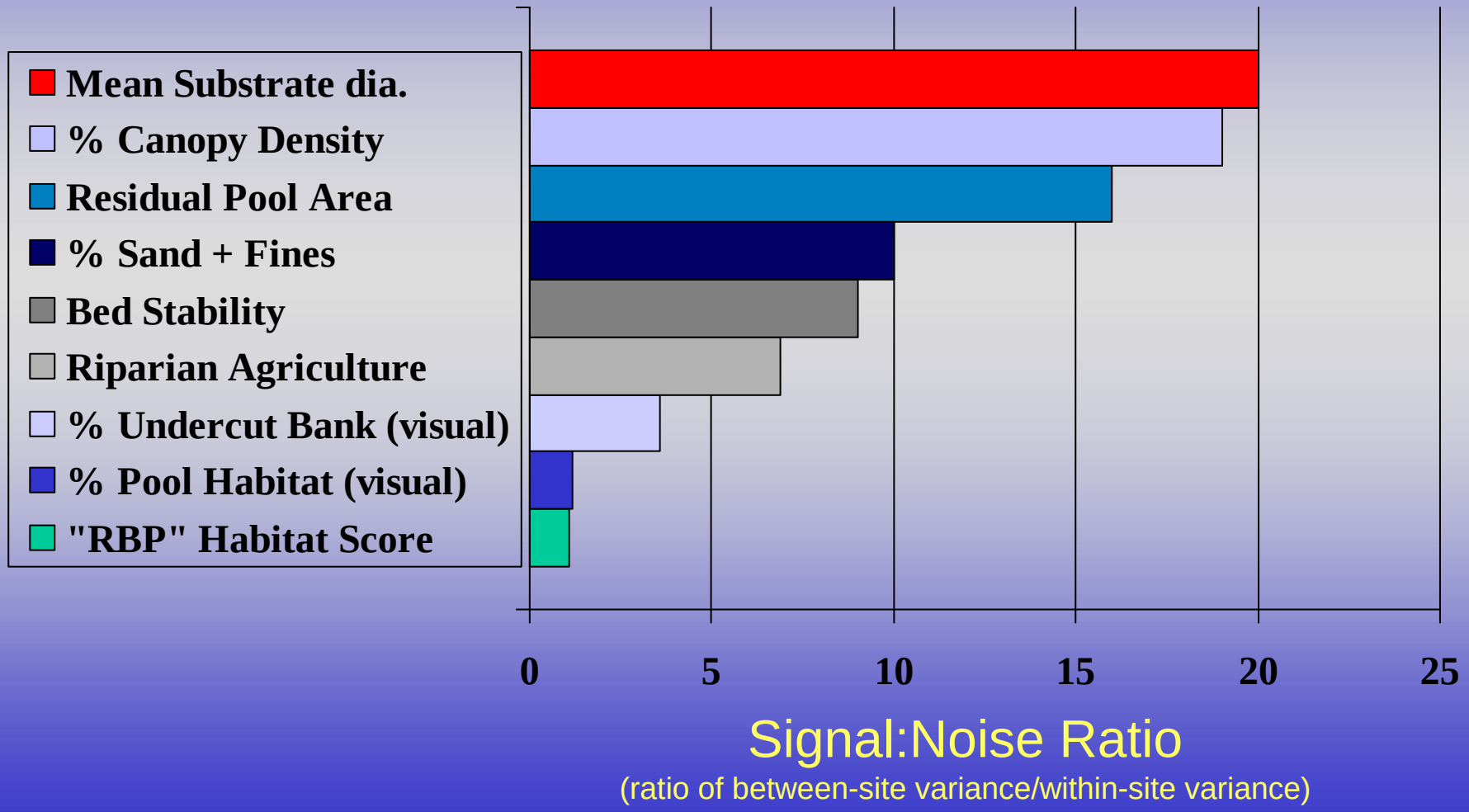


Indicator Approach

Indicator Criteria

- What can we (realistically) measure in a sample survey?
- How can we best measure it?
- *How variable is it?*
- How responsive is it?
- Can we score it?

Indicator Approach
How variable is it?



Indicator Approach

Indicator Criteria

- What can we (realistically) measure in a sample survey?
- How can we best measure it?
- How variable is it?
- *How responsive is it?*
- Can we score it?

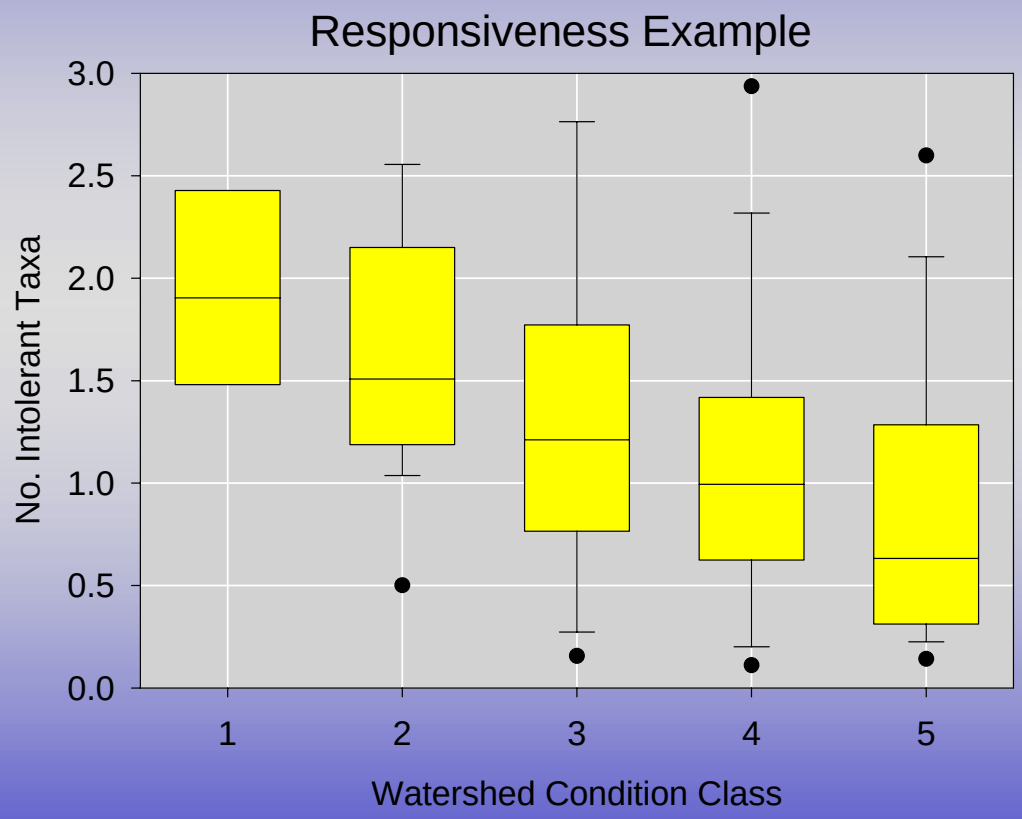
Indicator Approach
(Responsiveness)

Chemical Habitat:
- •pH
- •sulfate concentration
- •total nitrogen concentration
- •total phosphorus concentration

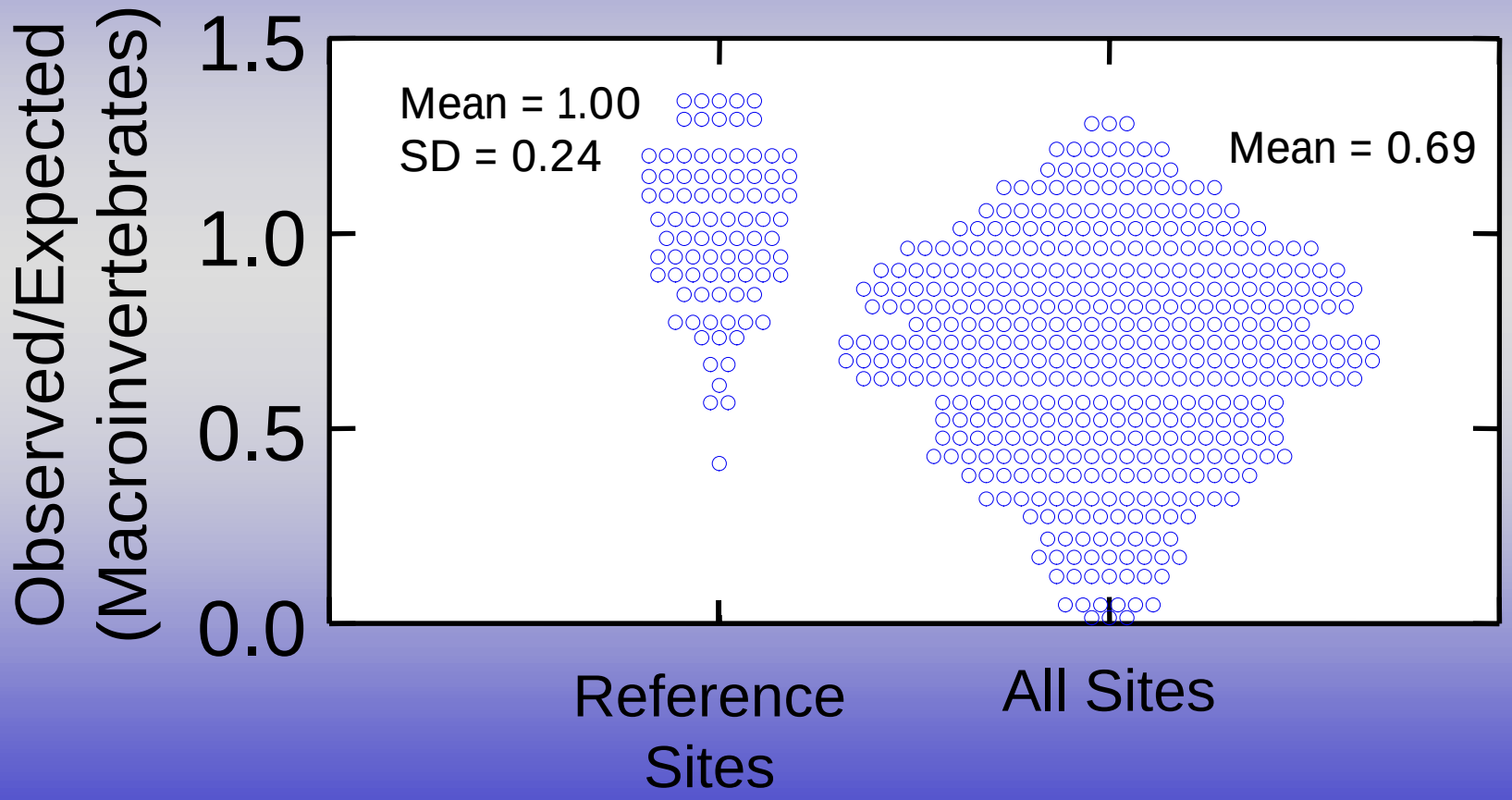
Physical Habitat:
- •Percent Sands and Fines
- •Bed Stability
- •Density of Large Woody Debris
- •Fish Cover
- •Riparian Disturbance
- •Channel and Riparian Disturbance Index
- •Watershed Quality Index
- •Watershed & Riparian Quality Index
- •Watershed, Riparian & Channel Habitat Quality Index
- •Channel Habitat Quality Index

Integrated Measures:
- •Disturbance Class (Mine Drainage, Acid Rain, Nutrients, etc.)
- •Watershed Condition Class

Natural drivers (included as a check):
- •Reach Slope



Indicator Approach
(Responsiveness)

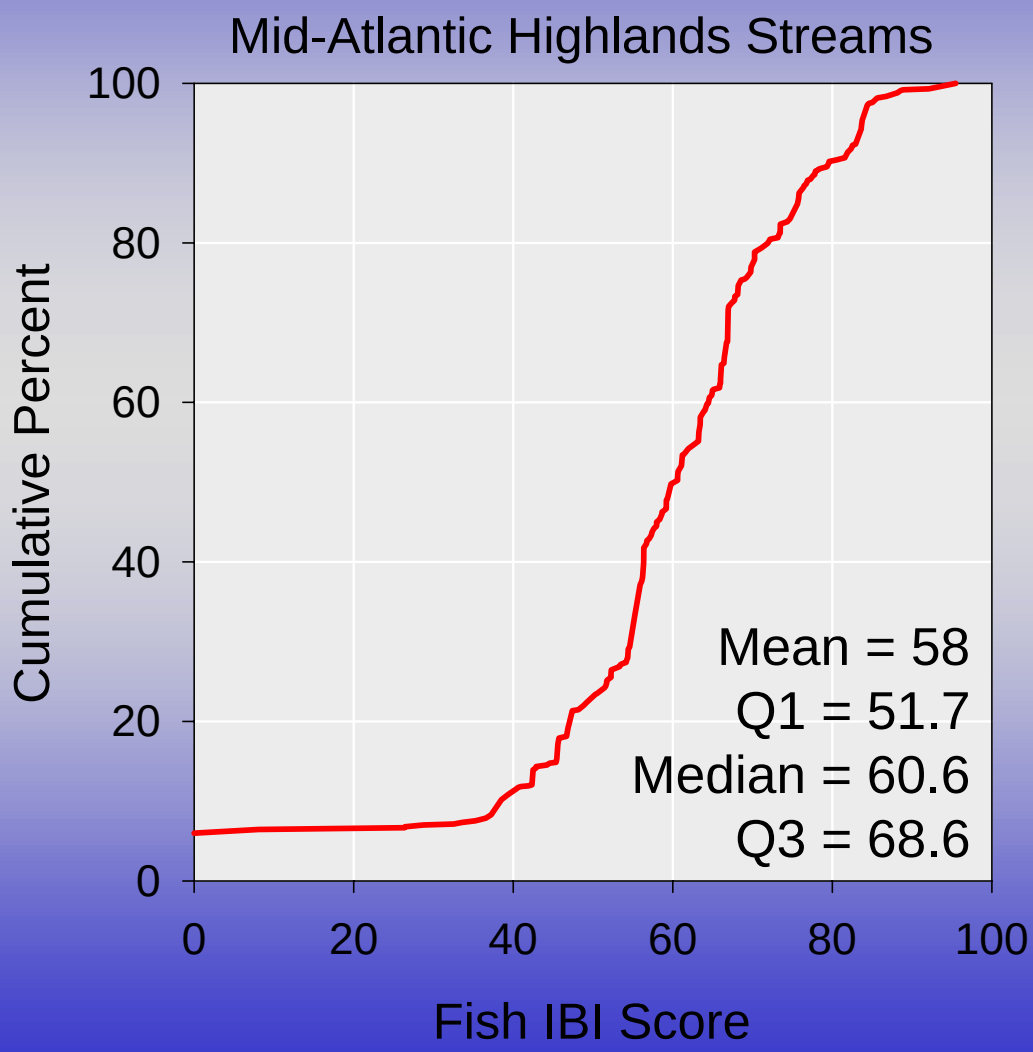


Indicator Approach

Indicator Criteria

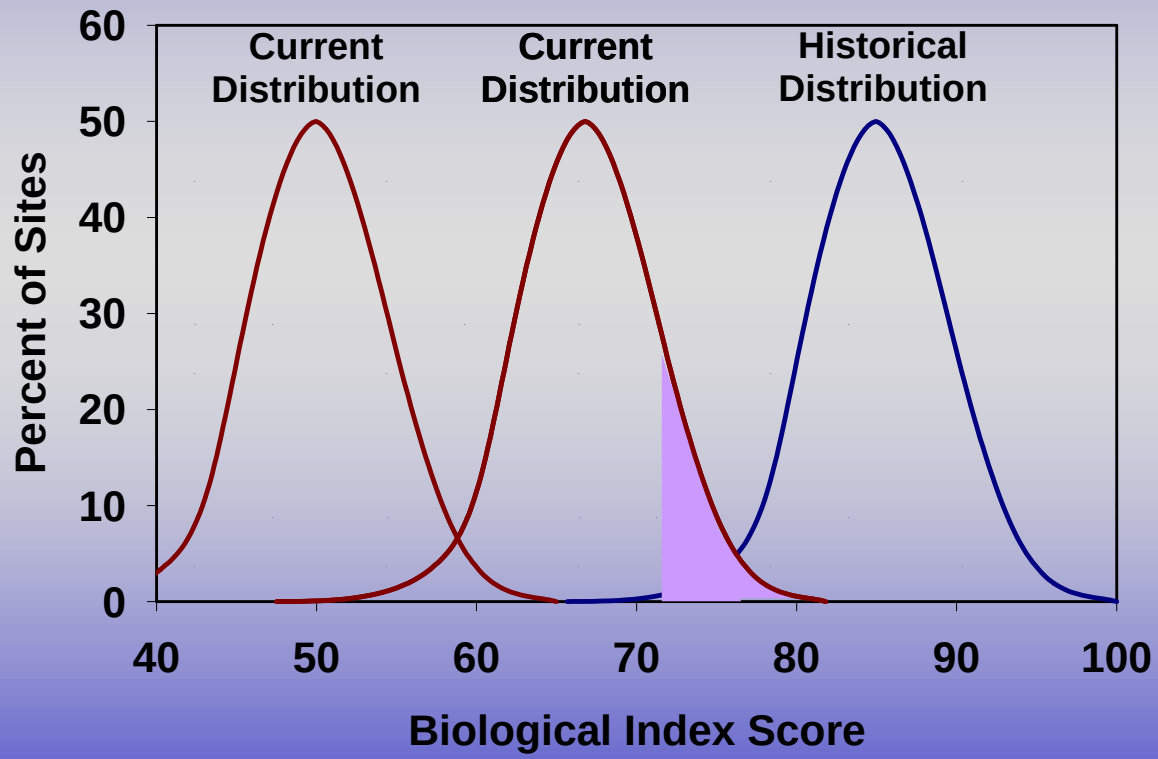
- What can we (realistically) measure in a sample survey?
- How can we best measure it?
- How variable is it?
- How responsive is it?
- *Can we interpret it?*

Example Statistical Summary Fish IBI



Reference Condition

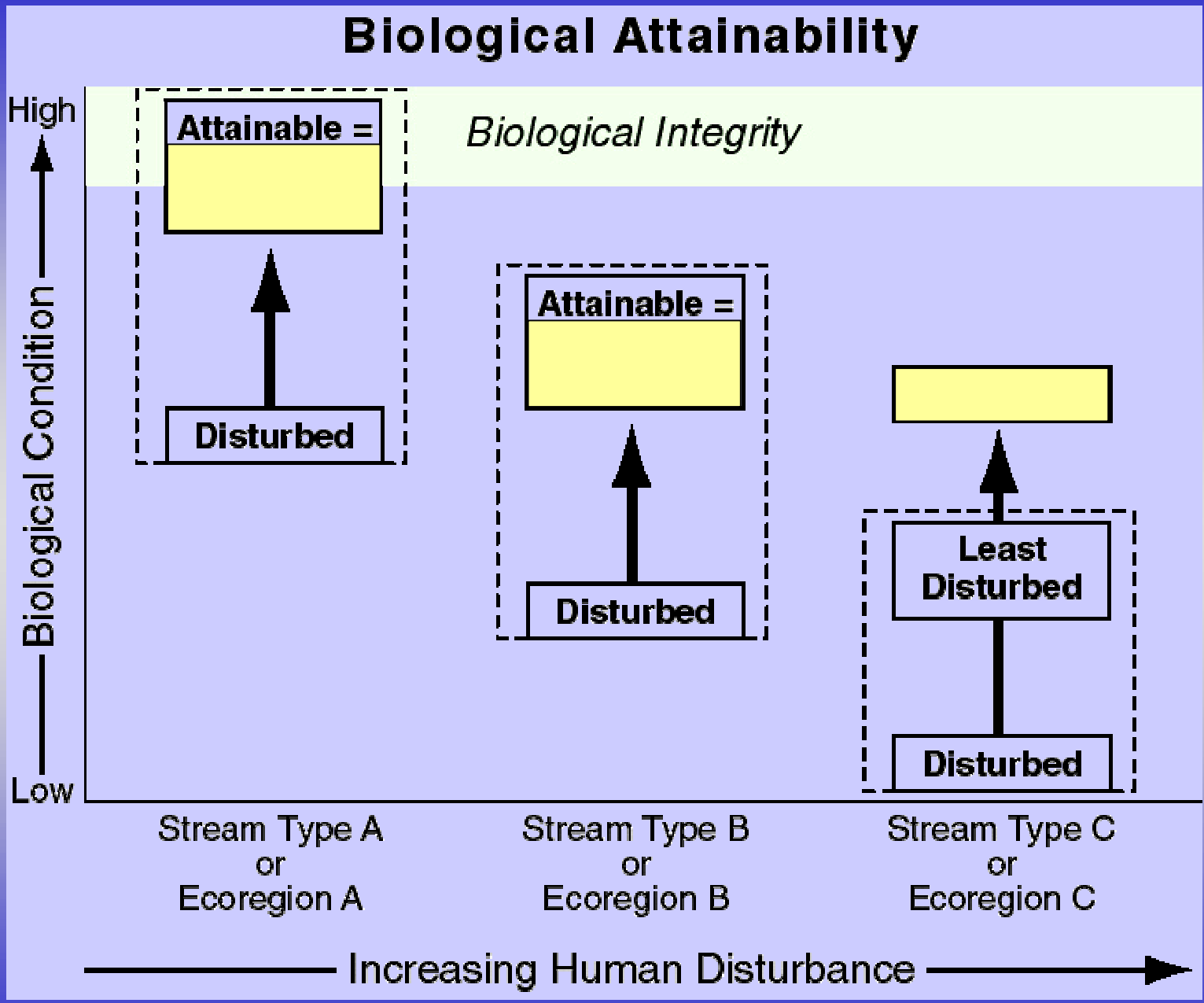
estimating distribution of sites in reference condition



Definitions of Reference Condition

For EMAP we recognize that multiple definitions exist, and that these 3 are especially pertinent:

- **Minimally Disturbed Condition** - condition of streams in the absence of significant human disturbance (e.g., "natural," "pristine" or "undisturbed")
- **Least Disturbed Condition** – found in conjunction with the best available physical, chemical and biological habitat conditions given today's state of the landscape – the "best of what's left"
- **Best Attainable Condition** – equivalent to the ecological condition of (hypothetical) least disturbed sites where the best possible management practices are in use

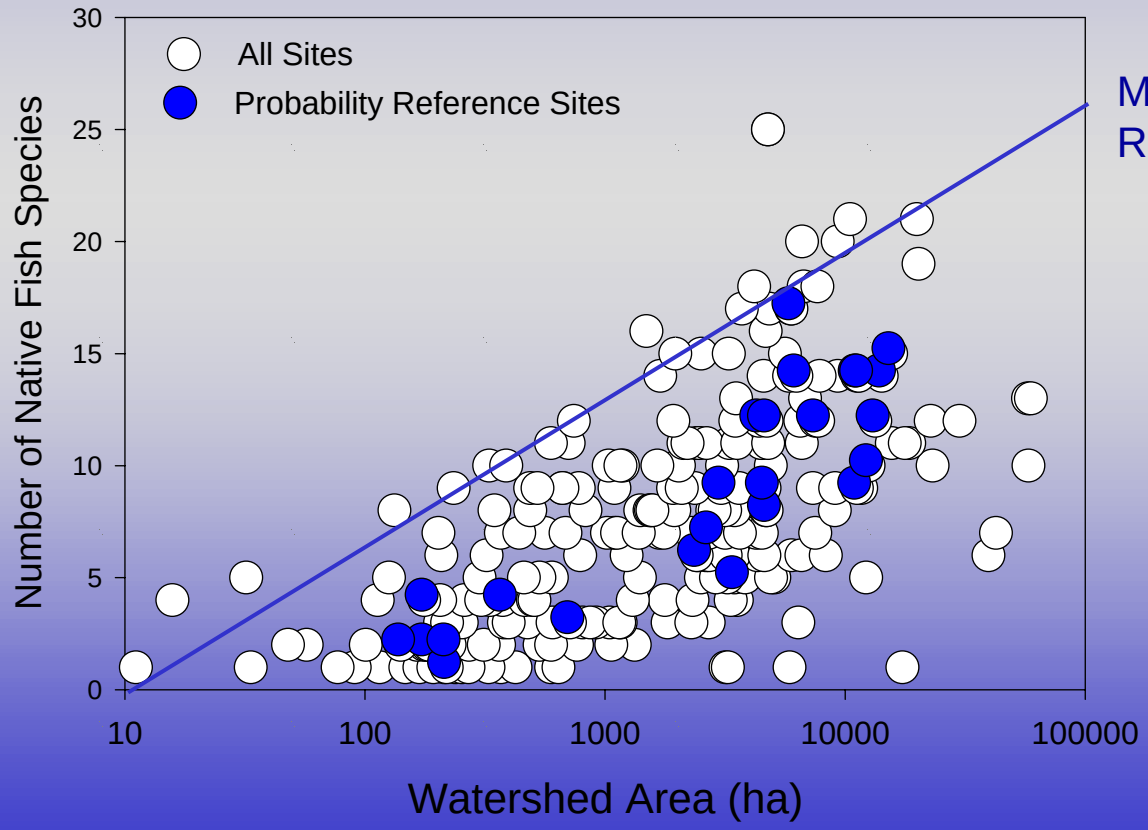

Biological Attainability
High
Biological Condition
Low
Attainable =
Biological Integrity
Disturbed
Attainable =
Disturbed
Least
Disturbed
Disturbed
Stream Type A
or
Ecoregion A
Stream Type B
or
Ecoregion B
Stream Type C
or
Ecoregion C
Increasing Human Disturbance

Methods for Characterizing Reference Condition

- Infer from data distributions
  - Maximum Species Richness lines
- Infer from ambient frequency distribution (CDF)
- Historical reconstruction
- Measuring condition at minimally stressed sites
  - Best professional judgment reference sites
  - “filtered” probability sites
  - using hand-picked sites to fill out distributions
- Modeling expected condition in absence of stressor

Maximum Species Richness Lines

IBI Development



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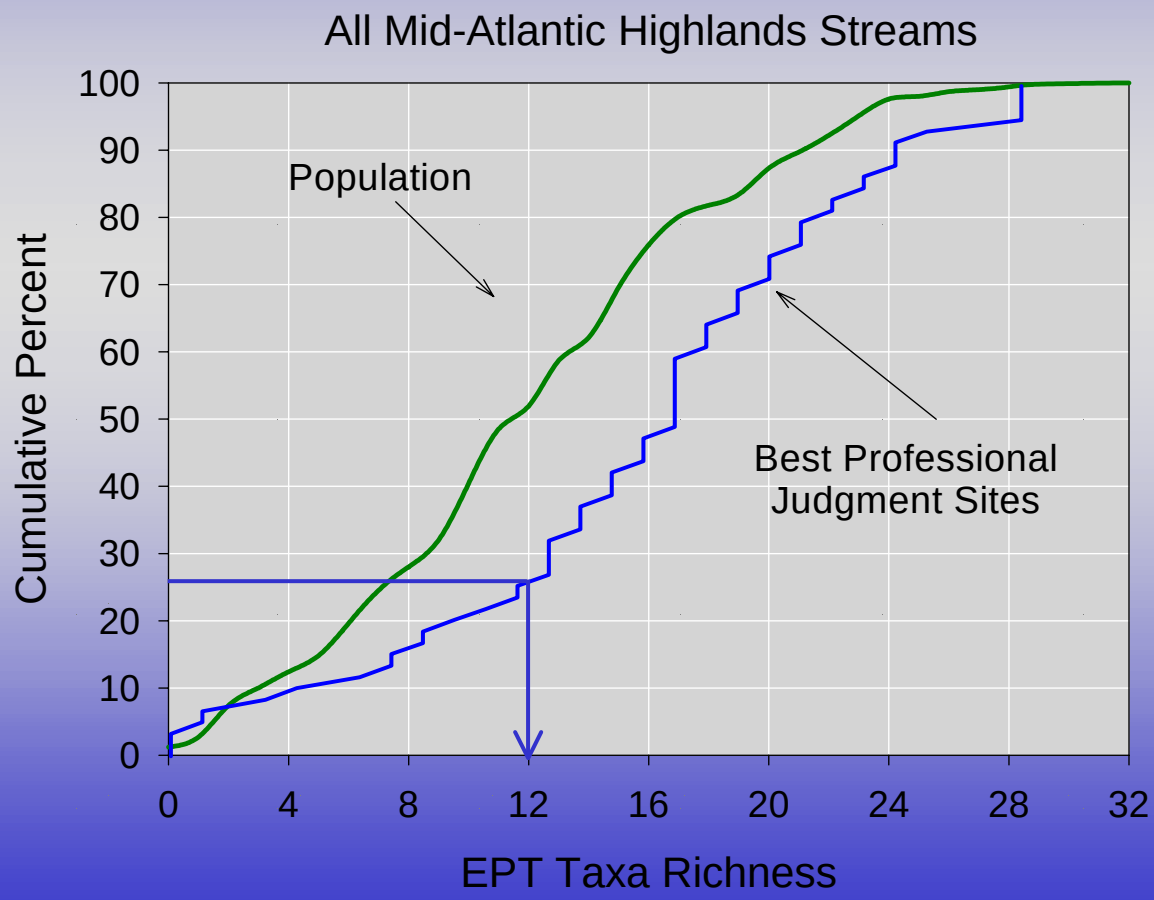
  - “filtered” probability sites

Filtering Sites

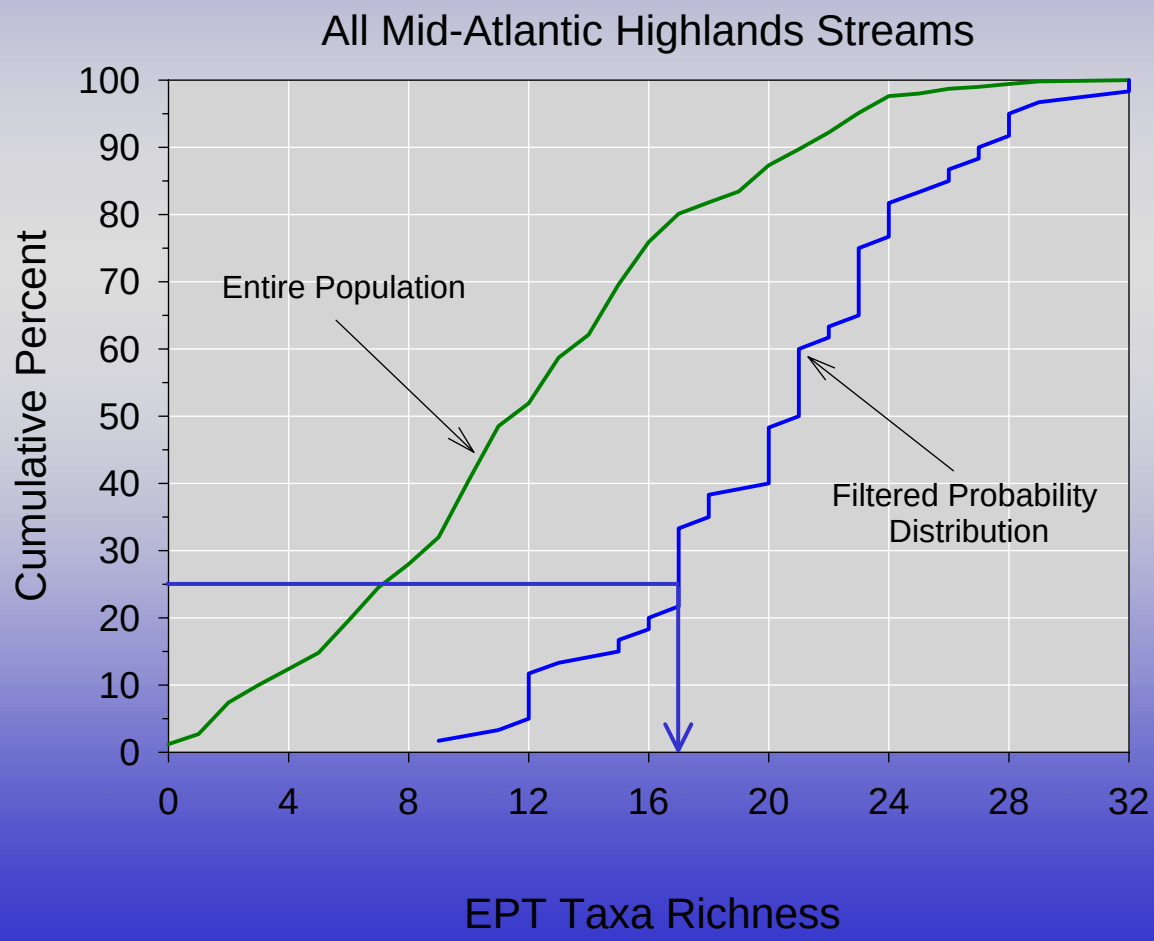
"Filters" on data: exclude all sites with:

- sulfate over 400 µeq/L (mine drainage)
- acid neutralizing capacity less than 50 µeq/L (acid rain)
- average RBP habitat score less than 16 (habitat)
- total phosphorus over 20 µg/L (nutrient enrichment)
- total nitrogen over 750 µg/L (nutrient enrichment)
- chloride over 100 µeq/L (general watershed disturbance)
- insufficient sample (< 100 macroinvertebrate individuals; watersheds < 2 sq. km. for fish)

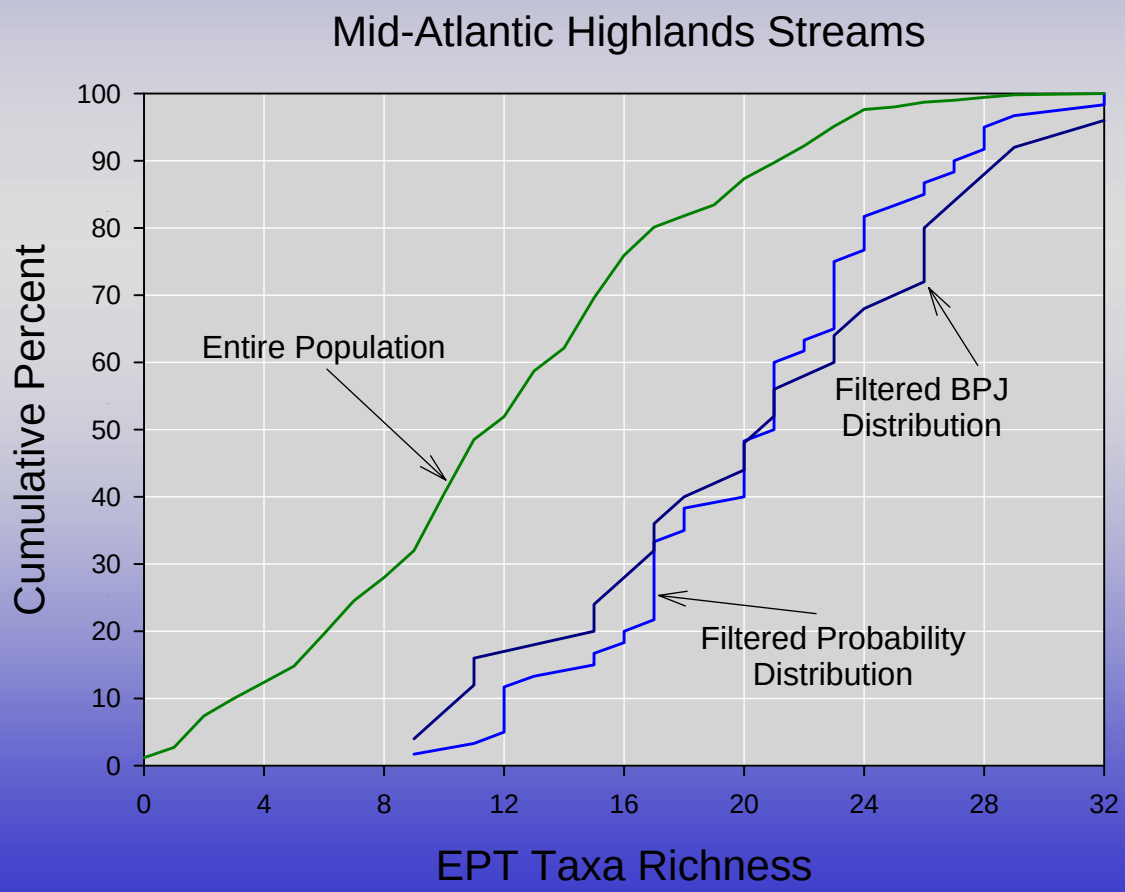
Measuring Condition at Reference Sites



Filtered Probability Reference Sites



Filtered Probability and BPJ Reference Sites

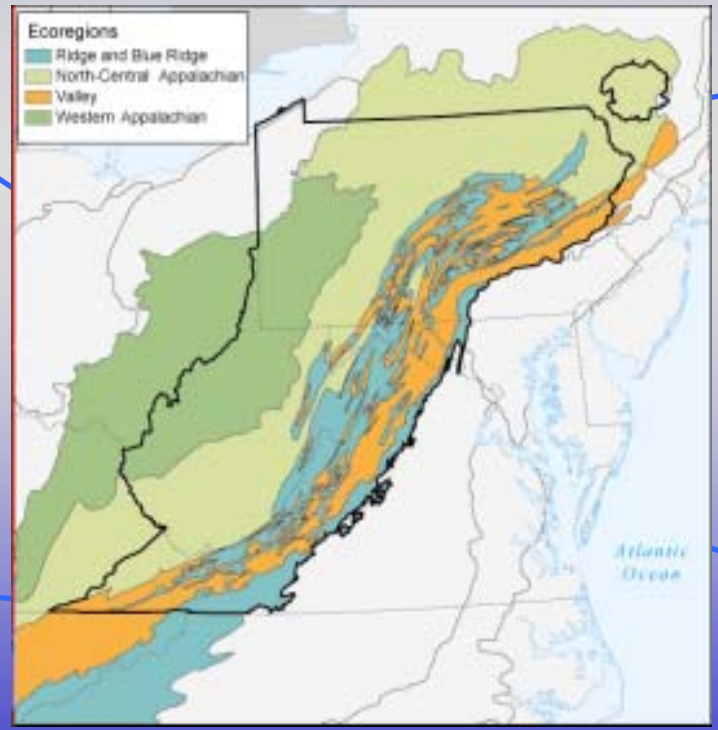


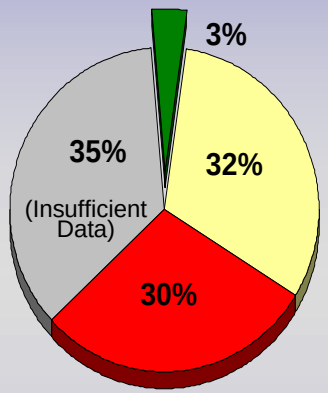
Reference Condition in EMAP-W

- **Goal is to estimate the distribution of indicator values in sites of Least Disturbed Condition** – the best of what's left
- **Estimating the distribution will require a sufficient sample size – minimum of 20 sites/state**
- **Multiple methods for finding sites in Least Disturbed Condition**
  - Best Professional Judgment
  - "filtered" probability sites
  - GIS screening
- All sites (regardless of selection method) will need to meet our definition, i.e., they will need to represent the best of the current distribution

Example EMAP Assessment of Ecological Condition

Fish Index of Biotic Integrity
example from Mid-Atlantic
(90% CI = ± 10%)





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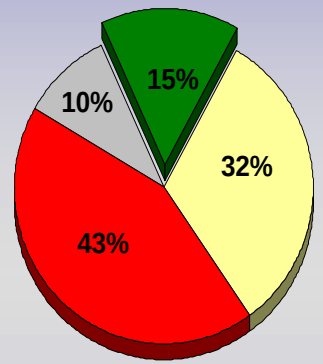

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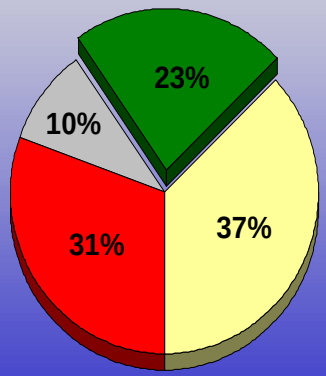
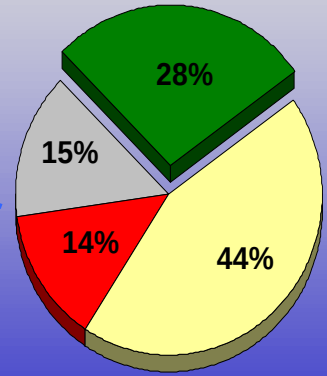


Valleys



Ridge and Blue Ridge

Summary

- Identify clear and concise assessment questions
- Identify quantitative characteristics for indicators
- Define process for identifying what you “expect” to find for the indicator
- Make sure indicators and design mesh to provide the answer
- Ensure that it is logistically feasible in a sustainable fashion